A Naval Postgraduate Dental School Analysis of Initial Endodontic Treatment

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A thesis submitted to the Faculty of the
Endodontics Graduate Program
Naval Postgraduate Dental School
Uniformed Services University of the Health Sciences
in partial fulfillment of the requirements for the degree of
Master of Science
in Oral Biology

June 2012

Naval Postgraduate Dental School
Uniformed Services University of the Health Sciences
Bethesda, Maryland

CERTIFICATE OF APPROVAL

MASTER'S THESIS

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Abstract
Clinicians need to have the ability to predict the prognosis of endodontic treatment to make informed decisions on treatment options. The prognosis of initial endodontic treatment is reported to be very favorable with high healing rates; however, several variables have been identified as possible contributors to decrease healing in previous research. **Objective:** To determine the outcome of initial endodontic treatment completed by Navy Endodontists and Residents at the Naval Postgraduate Dental School (NPDS) as well as to identify variables that affect the outcome of initial endodontic treatment. **Materials and Methods:** To assess healing, this study used both clinical and radiographic data gathered from a cohort of 112 subjects who received endodontic treatment at NPDS or from a Navy Endodontist and follow-up examination at least 12 months following treatment. Further analysis of the data were performed using Fisher's Exact Chi-squared, logistic regression and odds ratio analysis to evaluate the variables that potentially influence healing. **Results:** Of the 112 subjects enrolled in this study, a 66% healed rate was noted, indicating the absence of a radiographic lesion and clinical signs and symptoms at follow-up. However, a 96% clinical success rate was achieved, indicating the absence of clinical signs and symptoms. Further analysis indicated an association between an immediate post-obturation radiographic lesion ($p=0.002$) and pre-operative diagnosis of a necrotic pulp ($p=0.037$) negatively affected healing. Utilizing logistic regression, no other factors analyzed were noted to affect healing. Odds ratio analysis indicated a greater likelihood for healing when a radiographic lesion was absent (6.2x) and a vital pulp was present (3.3x). **Conclusion:** Preliminary evaluation indicated a healing rate of 66% with a clinical success of 96%. The presence of either a necrotic pulp or an immediate post-operative radiographic lesion was determined to significantly decrease healing outcomes.

Key Words
Outcome assessment, initial endodontic treatment, non-surgical root canal treatment, outcome of endodontic treatment, periapical healing

Introduction

The ability to predict the outcome of endodontic treatment is necessary to identify the most appropriate treatment plan for each patient. The varying criteria used to define success produces inconsistency in treatment outcome reports in endodontic literature. Variations range from the classification of "functional," which may refer to a tooth with persistent apical pathosis without clinical signs and symptoms, to "healing" when a decreasing size of apical lesion is present, to "healed" when an absence of radiographic and clinical signs and symptoms is demonstrated (1). For example, Brynolf (2) noted only 7% of anterior root canal treated teeth showed absence of inflammatory cells in periapical tissues. However, large epidemiologic studies that measured retention rates of endodontically treated teeth found a 97% survival rate at 8 years (3) and a 94% retention rate at 3.5 years (4).

Many variables complicate the ability to consistently achieve success in endodontics. The patient's medical condition may have a profound effect on successful treatment. In 2003, Fouad and Burleson (5) determined patients with diabetes had a significantly reduced success rate compared to non-diabetics in cases with pre-operative periapical lesions. In a literature review, Duncan and Pitt Ford (6) discussed the lack of evidence that smoking affects the incidence or healing of apical periodontitis. However, Doyle et al. (7) showed a significant correlation between smokers and non-healing. In 2006, Caplan et al. (8) showed a relationship between incidence and duration of lesions of endodontic origin and coronary heart disease (CHD) in men <40 years old. He later noted a correlation between endodontic treatment history and CHD prevalence (9).

Pre-existing conditions of the tooth may also impact initial endodontic treatment outcome. Field et al. (10) noted treatment on anterior teeth was more successful than on posterior teeth. Orstavik et al. (11) determined tooth type significantly affected outcome. Many studies (5, 12, 13, 14, 15, 16) have associated pre-operative symptoms and the pulp and periapical status of teeth with treatment outcome. In 2004, a meta-analysis by Kojima et al. (17) reported a significantly higher success rate for treatment of vital pulp versus non-vital cases. The presence of a radiographic lesion following non-surgical root canal therapy (NSRCT) was determined prognostic of decreased healing (18, 19). For molars, pre-operative periodontal condition correlated with NSRCT outcome at 4 years or more (20).

Intra-operative variables may also affect treatment outcome. Oliet (21) determined overextension of obturation materials significantly decreased healing outcome; however, number of treatment visits had no affect on healing. Smith et al. (22) reported a significantly higher healed rate in teeth with flush obturation vs. over- or under-extended obturation. Procedural complications such as perforation, over-instrumentation, and length of obturation have been cited as negatively affecting endodontic outcome (11, 13, 14). A systematic review published in 2010 by Ng, Mann and Gulabivala (23) noted significantly improved tooth survival following NSRCT with the presence of: (a) coronal restoration after treatment; (b) both mesial and distal proximal contacts; (c) a tooth not functioning as an abutment for a prosthesis; and (d) non-molar tooth type.

Determination of appropriate treatment depends upon recognizing predisposing factors and effectively employing techniques and materials. Currently, no study assesses the outcome of

initial NSRCT in the United States Navy patient population. The purpose of this observational study was to determine the healing rate of initial endodontic therapy and to identify variables affecting the NSRCT outcome for patients treated by Naval Postgraduate Dental School (NPDS) Endodontic Residents and Navy Endodontists.

Materials and Methods

The Walter Reed Military Medical Center Institutional Review Board approved this study. Study subjects were recruited using contact information in existing treatment logbooks, patient records, and walk-in patients presenting for treatment. Patients previously treated at NPDS, who were due for follow-up examinations, were also contacted. Patients at the NPDS Endodontic Clinic were informed of the clinical study. If the patient met the inclusion criteria and was interested in participating in the study, an IRB approved investigator, not involved with the treatment, introduced the study using a standardized script. If the patient agreed to participate in the study, consent and HIPAA forms were provided.

Inclusion criteria included: (a) having a history of initial NSRCT performed by only a NPDS Endodontic Resident or Navy Endodontist at least 12 months prior to the follow-up evaluation, (b) having at least one final-treatment radiograph available for review, and (c) being at least 18 years old. Exclusion criteria included: (a) NSRCT retreatment, (b) SRCT, or (c) canal obturation with any material other than gutta percha.

A power analysis determined the number of subjects for this study. Based on previously published literature (1, 4, 16), 85% was chosen as a conservative estimate of subjects that would heal after NSRCT. A 0.03 tolerable margin of error was chosen to give the study power sufficient to show significance in a large variety of data points and to help offset inconsistencies in the data that are due to the retrospective study design. With 85% estimated healing and a 0.03 margin of error, the necessary sample size was 545 enrollees. Six hundred subjects will be enrolled in the study to account for a 10% drop out rate.

Pre-operative and intra-operative data were collected from patient records and radiographs (Table 1). Follow-up data were collected from clinical and radiographic examinations $\geq$ 12 months after initial treatment. Each follow-up examination began by reviewing the patient's symptoms, medical questionnaire, and past dental history. The clinical examination included an extra-oral and intra-oral exam, palpation, percussion, periodontal probing, mobility, and pulp sensibility testing. The radiographic examination included 2 periapical radiographs and 1 bitewing radiograph. Data collected from the follow-up examination is in Table 1. Calibrated NPDS Endodontic Residents performed the clinical exams and recorded the data collected from patient records, as well as clinical and radiographic examinations, on standardized pre-operative, intra-operative, and post-operative data collection forms.

For evaluation of obturation fill length, the criteria were defined as: flush, within 2.0mm of the radiographic apex; overextended, excess beyond the radiographic apex; and under-extended, >2.0mm short of the radiographic apex (22).

Radiographs were taken digitally with Kodak RVG 6100 (Carestream Dental LLC, Atlanta, GA) sensors and Schick (Schick Technologies Inc, Long Island City, NY) sensors or conventionally with Kodak Insight (Carestream Dental LLC, Atlanta, GA) film and developed in a Peri Pro III

(Air Techniques Inc, Hicksville, NY). Radiographs taken with film were digitized by a HP PhotoSmart S20 scanner (Hewlett-Packard Company, Palo Alto, CA) and secured on a departmental computer with an individualized password. Radiographs were entered into Microsoft PowerPoint (Microsoft Corporation, Redmond, WA), magnified to a standard size, and displayed on a black background. The crown of each tooth was blocked out to eliminate scoring bias based on the tooth's restoration status.

Radiographs were projected onto a 35" x 50" screen in a darkened room and displayed in random order determined by a random number generator (www.random.org). Periapical status was determined by a forced consensus of three calibrated board certified endodontists, and assigned a periapical index (PAI) score established by Orstavik, et al. (24). The examiners were calibrated using selected radiographs and a PAI standard reference set forth by Orstavik.

Determination of outcome was based on combined clinical and radiographic assessment and measured as healed or not-healed. If the clinical exam was free of pain, swelling, sinus tract, percussion sensitivity, palpation sensitivity, and tooth mobility, and if the radiograph assigned PAI score was 1-2, the tooth was considered healed. The presence of clinical signs or symptoms or a PAI score of 4-5 was determined not-healed. If the tooth was clinically normal and had a PAI score of 4-5, the tooth was further classified as functional (1). Follow-up radiographs with a PAI score of 3 were determined "uncertain" and omitted from statistical analysis. The intra-observer agreement was analyzed and produced a Cohen kappa of 0.63.

Data Analysis

Statistical evaluation was performed using SPSS v15.0 (SPSS Inc, Chicago, IL). Preliminary data were gathered on 112 subjects. Due to the retrospective nature of the study, pre- and peri-operative data were missing on 9 of the 112 enrollees. An additional 30 subjects with post-operative PAI scores of 3 were omitted from the statistical analysis. This made a sample size of 73 subjects available for statistical analysis. Data for the 73 subjects were analyzed using descriptive, chi-squared, odds ratio and logistic regression analysis.

Results

The 73 subjects had follow-up periods ranging from 12 months to 10.5 years with the average being 14 months. Of these, 48 (66%) teeth had absence of apical radiolucency and absence of clinical signs and symptoms, indicating a "healed" status. Of the 25 teeth in the "non-healed" group, 22 (30%) presented with apical pathosis, but no clinical signs or symptoms, and three teeth (4%) presented with percussion sensitivity. At follow-up, 70 of 73 (96%) teeth presenting without clinical signs or symptoms were determined functional (Figure 1).

Fischer's Exact Chi-squared analysis indicated statistical significance ($p<0.05$) between the presence of a post-obturation radiolucency and healing ($p=0.002$) and a vital pulp and healing ($p=0.037$). Using common odds ratio, a tooth with a post-operative radiolucency was found 6.2 times more likely not to heal when compared to a tooth with no radiolucency at treatment time. Also, a tooth with a necrotic pulp was 3.3 times more likely not to heal compared to one with a vital pulp.

Factors found not to affect healing based on Fisher's Exact Chi-squared test were procedural complications ($p=0.053$), patency ($p=0.069$), tooth type ($p=0.083$), single vs. multiple visits

(p=0.086), gender (p=0.296), permanent coronal restoration (p=0.316), obturation fill length (p=0.400), CHD (p=0.547), diabetes (p=0.609), age (p=0.687), hypertension (p=1.00) and presence of pre-operative pain (p=1.00).

Logistic regression modeling showed no additional factors to be predictive of healing outcomes.

Discussion

This preliminary analysis showed 66% of the teeth were considered healed. This healed rate is considerably lower than other studies with similar outcome measures (16, 25, 26). This could be attributed to the primary method of subject recruitment, which included inviting patients to return to the clinic for evaluation after one year. A symptomatic patient is more likely than an asymptomatic patient to return for evaluation. The recall rate of the target patient population was estimated to be less than 10%. Therefore, the healing rate is not an accurate indication for the entire U.S. Navy population. Another potential reason for lower than expected healing is this analysis did not consider diminishing radiographic lesions that indicate a healing process yet to be completed. According to Friedman, 1-year following endodontic treatment 90% of teeth that eventually healed showed detectable signs of healing; however, less than 50% were considered fully healed (1).

The retrospective nature of this study presents an additional limitation. The angle and diagnostic quality of the post-obturation and follow-up radiographs could not be controlled. Radiographs have limited ability to detect pathosis. Of the 103 subjects with complete sets of data, 30 (29%) follow-up radiographs received a PAI score of 3 and were excluded from the study. Of those 30 radiographs, 29 of the patients were asymptomatic and showed no clinical signs or symptoms.

The results of this study demonstrated 96% of the teeth were functional, as indicated by 70 of 73 subjects who presented at follow-up without clinical signs or symptoms. This percentage compares favorably with Salehrabi and Rotstein (3), de Chevigny et al. (16), and Ng et al. (27) who reported 95%-97% of endodontically treated teeth were functional at the long-term follow-up appointment. The presence of post-obturation radiolucency significantly decreased the likelihood of healing. This supports the findings of several studies showing similar results (12, 13, 15, 22, 25). de Chevigny et al. (16) determined that 93% of initial NSRCT cases without an apical radiolucency healed versus 83% of cases with a radiolucency.

The presence of a vital pulp at time of treatment was found to be significantly associated with healing. This finding is in agreement with Smith et al. (22) and Cotton et al. (12). However, both Oliet (21) and Imura et al. (13) reported pulp status was not significantly associated with healing.

Conclusion

Preliminary data analysis demonstrates a 66% healed rate based on the strict absence of radiographic and clinical signs or symptoms at a minimum of one-year follow-up. Additionally, 96% of the teeth were functional, as indicated by 70 of 73 subjects who presented at follow-up without clinical signs or symptoms.

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Figure 1. Percentage of patients healed, not healed, and functional.

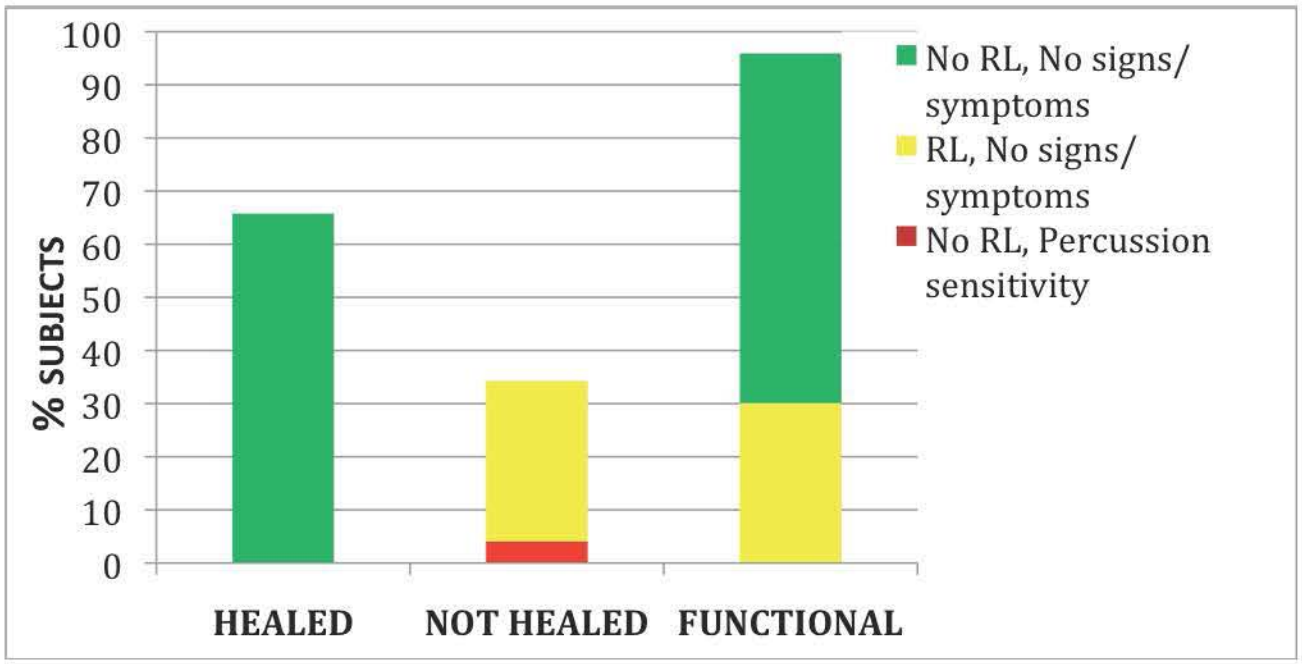

Table 1. Data points (preoperative, intraoperative, and follow-up) to be collected from patient records and examinations.

Preoperative

Age
Tooth #
Tooth type
Medical conditions
- Hypertension
- Smoker
- Diabetes Type:____
- Coronary heart disease

Symptoms
Pain (0-10)
Can locate pain by quadrant
Can locate pain by tooth
Electric pulp tester EPT
Palpation
Sinus tract
Swelling
History (hx) of orthodontics
Hx of external resorption
Presence of intracanal post
Caries
Cold sensitivity
Percussion
Mobility
Bleeding on probing
History (hx) of bleaching
Hx of internal resorption
Open restorative margin
Restoration present
Duration of symptoms
Probing depths
Intact lamina dura
Radiolucency size
Preoperative pulpal diagnosis (dx)
Preoperative ~~peri~~apical dx

Intraoperative

Electronic apex locator used
Patency achieved
Type of irrigants used
Calcium hydroxide use
Procedural complications
Use of intraorifice barrier
# of treatment sessions
Obturation fill length
Postoperative pulpal dx
Postoperative periapical dx
Date of treatment completion
Final treatment PAI score

Follow-up

Date of follow-up exam
Medical conditions
- Hypertension
- Smoker
- Diabetes Type:____
- Coronary heart disease

Symptoms
Pain (0-10)
Electric pulp tester EPT
Palpation
Sinus tract
Swelling
Time lapse to restoration
Duration of symptoms
Cold sensitivity
Percussion
Mobility
Periodontal screening
Bleeding on probing
Probing Depths
Intact lamina dura
Radiolucency size
Follow up apical diagnosis
Caries
Presence of coronal restoration
Presence of intracanal post
Open restorative margin
Follow-up PAI score